# Measuring Energy Demand

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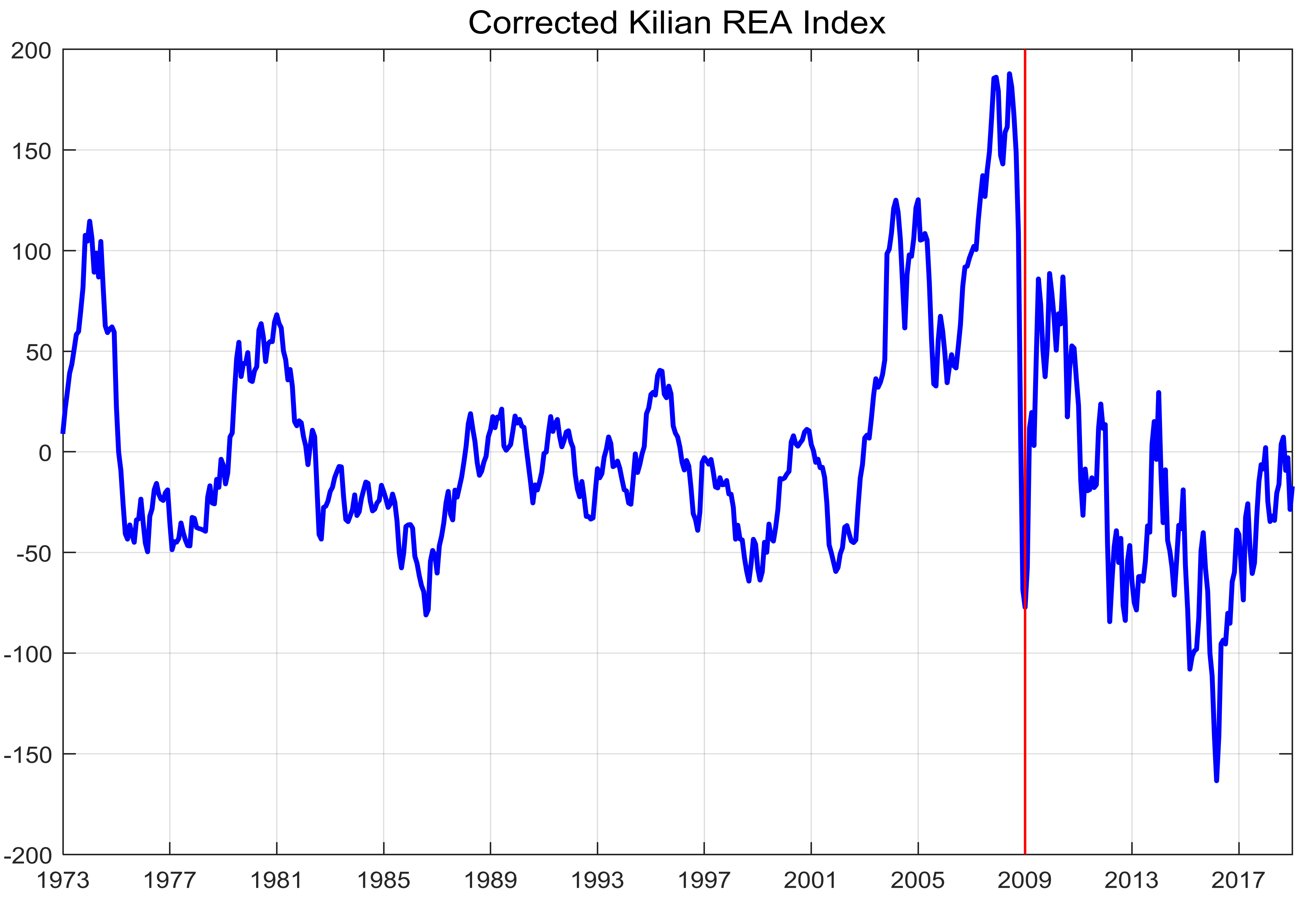
# Motivation

- Alquist, Kilian, and Vigfusson (2011) showed that a VAR model of the global oil market can beat the no-change forecast for oil prices at short horizons (1-6 months)

- Model includes past values of
  - real refiner's acquisition cost of imported crude oil (RAC)
  - percent change of global crude oil production
  - change in global crude oil inventories
  - proxy for global real economic activity

- Proxy for global activity: Kilian REA index
  - coding error
  - recently extremely volatile
  - at odds with anecdotal evidence


Corrected Kilian REA Index
200
150
100
50
0
-50
-100
-150
-200
1973
1977
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017

# Outline

- Revisit evidence for forecasting performance
  - ➢ corrected index and other transformations of shipping costs
  - ➢ updated evaluation period
  - ➢ Brent price instead of RAC

- Compare with alternative measures for monthly global real economic activity proposed in the literature:
  - ➢ World industrial production index (Baumeister and Hamilton, 2019)
  - ➢ Factor extracted from a panel of real commodity prices (Delle Chiaie, Ferrara, and Giannone, 2017; Alquist, Bhattarai, and Coibion, 2019)
  - ➢ World steel production (Ravazzolo and Vespignani, 2019)

# Beyond Price Forecasts

- Construct global activity factor from a large dataset where variable selection is guided by determinants of energy demand

- Enhance understanding of developments on the demand side
  ⇨ forecast global petroleum consumption
  ⇨ use expected growth as indicator of future energy demand

# Global dataset

- Broad coverage in terms of variables and countries
- 8 groups of variables

1. Macroeconomic variables

   world IP, steel production, PMI, CFNAI, Eurocoin, business and consumer confidence indices, retail trade, unemployment rate, leading indicators, capacity utilization, consumption expenditures

2. Financial variables

   stock prices for energy-intensive sectors, exchange rates, financial conditions indicators, interest rates and spreads

3. Real commodity prices

   aluminum, copper, zinc, rubber, tin, cotton, palm oil, soybeans, wheat

4. Uncertainty measures

   geopolitical risk, volatility of oil, gasoline and natural gas prices, VIX

# Global dataset

5. Weather-related data

   El Nino, heating-degree days, cooling-degree days, global temperature anomalies

6. Transportation sector

   passenger car registration, vehicle production, miles traveled, rail freight

7. Expectations measures

   expected change in income, unemployment, business conditions, interest rates, index of consumer expectations, spread between long-run and short-run price expectations of oil, gasoline, heating oil and natural gas

8. Energy-related data

   electricity consumption, energy production and distribution, carbon dioxide emissions, gasoline and petroleum stocks

⇨ 195 variables at monthly frequency

# Forecasting Environment

- Recursive out-of-sample forecasting
  $\Rightarrow$ first estimation period: 1973M1–1991M12
  $\Rightarrow$ evaluation period: 1992M1–2018M8
- Mean-square prediction error (MSPE)
  $\Rightarrow$ loss function: level of oil price and consumption
  $\Rightarrow$ benchmark for real oil price: random walk
  $\Rightarrow$ benchmark for consumption: AR(12) model
- Forecast horizons $h = 3, 6, 9, 12, 18, 24$ months ahead
- Lag length $p = 12$

# Forecasting the Real Refiner's Acquisition Cost

Recursive MSPE ratios relative to no-change forecast

| Monthly horizon | Kilian index (REA BDI) | REA *Shipping Insight* | PC real shipping costs | World IP index | PC real commodity prices | PC steel production | Global activity factor |
|---|---|---|---|---|---|---|---|
| | Evaluation period: 1992.1-2010.6 | | | | | | |
| 1 | **0.679**$^{**}$ | **0.679**$^{**}$ | **0.703**$^{**}$ | **0.657**$^{**}$ | **0.723**$^{**}$ | **0.694**$^{**}$ | **0.725**$^{**}$ |
| 3 | **0.779** | **0.777** | **0.806** | **0.728** | **0.780** | **0.776** | **0.839** |
| 6 | **0.989** | **0.972** | **0.956** | **0.867** | **0.912** | **0.925** | **0.981** |
| 9 | 1.115 | 1.087 | 1.025 | **0.988** | 1.048 | 1.000 | 1.025 |
| 12 | 1.099 | 1.093 | **0.992** | **0.975** | 1.021 | **0.940** | **0.976** |
| 18 | 1.083 | 1.068 | **0.962** | **0.975** | **0.956** | **0.946** | **0.942** |
| 24 | 1.122 | 1.133 | 1.071 | 1.095 | **0.995** | 1.054 | 1.028 |

Notes: **Bold** indicates that model performs better than random walk;
Red indicates the best model among the shipping indices;
Blue indicates the best model among the alternative global economic activity indicators.

# Forecasting the Real Refiner's Acquisition Cost

Recursive MSPE ratios relative to no-change forecast

| Monthly horizon | Kilian index (REA BDI) | REA *Shipping Insight* | PC real shipping costs | World IP index | PC real commodity prices | PC steel production | Global activity factor |
|---|---|---|---|---|---|---|---|
| | | | Evaluation period: 1992.1-2010.6 | | | | |
| 1 | **0.679**** | **0.679**** | **0.703**** | **0.657**** | **0.723**** | **0.694**** | **0.725**** |
| 3 | **0.779** | **0.777** | **0.806** | **0.728** | **0.780** | **0.776** | **0.839** |
| 6 | **0.989** | **0.972** | **0.956** | **0.867** | **0.912** | **0.925** | **0.981** |
| 9 | 1.115 | 1.087 | 1.025 | **0.988** | 1.048 | 1.000 | 1.025 |
| 12 | 1.099 | 1.093 | **0.992** | **0.975** | 1.021 | **0.940** | **0.976** |
| 18 | 1.083 | 1.068 | **0.962** | **0.975** | **0.956** | **0.946** | **0.942** |
| 24 | 1.122 | 1.133 | 1.071 | 1.095 | **0.995** | 1.054 | 1.028 |
| | | | Evaluation period: 1992.1-2018.8 | | | | |
| 1 | **0.865** | **0.824*** | **0.804*** | **0.765**** | **0.781**** | **0.795**** | **0.806*** |
| 3 | **0.955** | **0.912** | **0.911** | **0.852** | **0.841** | **0.911** | **0.963** |
| 6 | 1.074 | 1.041 | 1.008 | **0.972** | **0.933** | 1.025 | 1.094 |
| 9 | 1.154 | 1.110 | 1.044 | 1.061 | 1.036 | 1.067 | 1.113 |
| 12 | 1.159 | 1.117 | 1.031 | 1.069 | 1.038 | 1.045 | 1.074 |
| 18 | 1.087 | 1.042 | **0.997** | **0.979** | **0.948** | **0.967** | **0.950** |
| 24 | 1.045 | 1.010 | 1.000 | **0.941** | **0.925** | **0.946** | **0.896** |

Notes: **Bold** indicates that model performs better than random walk;
Red indicates the best model among the shipping indices;
Blue indicates the best model among the alternative global economic activity indicators.

# Forecasting the Real Brent Price

Recursive MSPE ratios relative to no-change forecast: 1992.1-2018.8

| Monthly horizon | Kilian index (REA BDI) | REA *Shipping Insight* | PC real shipping costs | World IP index | PC real commodity prices | PC steel production | Global activity factor |
|---|---|---|---|---|---|---|---|
| | Real Refiner's Acquisition Cost of Imported Crude Oil | | | | | | |
| 1 | **0.865** | **0.824***| **0.804*** | **0.765**** | **0.781**** | **0.795**** | **0.806*** |
| 3 | **0.955** | **0.912** | **0.911** | **0.852** | **0.841** | **0.911** | **0.963** |
| 6 | 1.074 | 1.041 | 1.008 | **0.972** | **0.933** | 1.025 | 1.094 |
| 9 | 1.154 | 1.110 | 1.044 | 1.061 | 1.036 | 1.067 | 1.113 |
| 12 | 1.159 | 1.117 | 1.031 | 1.069 | 1.038 | 1.045 | 1.074 |
| 18 | 1.087 | 1.042 | **0.997** | **0.979** | **0.948** | **0.967** | **0.950** |
| 24 | 1.045 | 1.010 | 1.000 | **0.941** | **0.925** | **0.946** | **0.896** |
| | Real Brent price of crude oil | | | | | | |
| 1 | 1.075 | 1.023 | **0.998** | **0.946** | **0.961** | **0.997** | 1.003 |
| 3 | 1.072 | 1.027 | 1.027 | **0.953** | **0.970** | 1.044 | 1.084 |
| 6 | 1.172 | 1.129 | 1.087 | 1.060 | 1.021 | 1.105 | 1.174 |
| 9 | 1.208 | 1.146 | 1.065 | 1.088 | 1.069 | 1.101 | 1.149 |
| 12 | 1.215 | 1.151 | 1.045 | 1.070 | 1.037 | 1.052 | 1.079 |
| 18 | 1.161 | 1.103 | 1.031 | **0.994** | **0.965** | **0.990** | **0.978** |
| 24 | 1.095 | 1.041 | 1.019 | **0.938** | **0.922** | **0.944** | **0.910** |

Notes: **Bold** indicates that model performs better than random walk;
Red indicates the best model among the shipping indices;
Blue indicates the best model among the alternative global economic activity indicators.

# Comparing VARs and Bayesian VARs

- Unrestricted least squares vs Bayesian shrinkage methods

Recursive MSPE ratios relative to no-change forecast: 1992.1-2018.8

| | Kilian index (REA BDI) | | REA *Shipping Insight* | | PC real shipping costs | |
|---|---|---|---|---|---|---|
| **Monthly horizon** | VAR(12) | BVAR(12) | VAR(12) | BVAR(12) | VAR(12) | BVAR(12) |
| 1 | 1.075 | **0.983** | 1.023 | **0.950** | **0.998** | **0.930** |
| 3 | 1.072 | 1.063 | 1.027 | 1.014 | 1.027 | **0.965** |
| 6 | 1.172 | 1.158 | 1.129 | 1.101 | 1.087 | 1.003 |
| 9 | 1.208 | 1.211 | 1.146 | 1.153 | 1.065 | 1.006 |
| 12 | 1.215 | 1.237 | 1.151 | 1.174 | 1.045 | **0.974** |
| 18 | 1.161 | 1.179 | 1.103 | 1.126 | 1.031 | **0.954** |
| 24 | 1.095 | 1.092 | 1.041 | 1.052 | 1.019 | **0.927** |

Notes: **Bold** indicates that model performs better than random walk;

Green indicates whether VAR or BVAR does better;

Red indicates the best model among the shipping indices.

# Comparing VARs and Bayesian VARs

- Unrestricted least squares vs Bayesian shrinkage methods

Recursive MSPE ratios relative to no-change forecast: 1992.1-2018.8

| | World IP index | | PC real commodity prices | | PC steel production | | Global activity factor | |
|---|---|---|---|---|---|---|---|---|
| **Monthly horizon** | VAR(12) | BVAR(12) | VAR(12) | BVAR(12) | VAR(12) | BVAR(12) | VAR(12) | BVAR(12) |
| 1 | **0.946** | **0.893***| **0.961** | **0.896*** | **0.997** | **0.934** | 1.003 | **0.925** |
| 3 | **0.953** | **0.910** | **0.970** | **0.918** | 1.044 | **0.983** | 1.084 | **0.979** |
| 6 | 1.060 | **0.972** | 1.021 | **0.967** | 1.105 | 1.032 | 1.174 | 1.049 |
| 9 | 1.088 | **0.999** | 1.069 | 1.006 | 1.101 | 1.033 | 1.149 | 1.054 |
| 12 | 1.070 | **0.971** | 1.037 | **0.968** | 1.052 | **0.983** | 1.079 | 1.007 |
| 18 | **0.994** | **0.947** | **0.965** | **0.932** | **0.990** | **0.955** | **0.978** | **0.960** |
| 24 | **0.938** | **0.922** | **0.922** | **0.898** | **0.944** | **0.927** | **0.910** | **0.913** |

Notes: **Bold** indicates that model performs better than random walk;

Green indicates whether the VAR or BVAR does better;

Blue indicates the best model among the alternative global economic activity indicators.

# Production vs Consumption

- Replace oil production with petroleum consumption

Recursive MSPE ratios relative to no-change forecast: 1992.1-2018.8

| | Kilian index (REA BDI) | | REA *Shipping Insight* | | PC real shipping costs | |
|---|---|---|---|---|---|---|
| **Monthly horizon** | VAR(12) | BVAR(12) | VAR(12) | BVAR(12) | VAR(12) | BVAR(12) |
| 1 | 1.078 | **0.964** | 1.017 | **0.931** | **0.986** | **0.918***|
| 3 | 1.075 | 1.045 | 1.020 | **0.998** | **0.984** | **0.942** |
| 6 | 1.164 | 1.138 | 1.124 | 1.091 | 1.019 | **0.966** |
| 9 | 1.237 | 1.219 | 1.189 | 1.164 | 1.032 | **0.987** |
| 12 | 1.287 | 1.267 | 1.238 | 1.209 | 1.041 | **0.979** |
| 18 | 1.242 | 1.209 | 1.189 | 1.160 | 1.022 | **0.957** |
| 24 | 1.152 | 1.114 | 1.124 | 1.081 | 1.018 | **0.938** |

Notes: **Bold** indicates that the model performs better than the random walk;
Green indicates whether the VAR or BVAR does better;
Red indicates the best model among the shipping indices.

# Production vs Consumption

- Replace oil production with petroleum consumption

Recursive MSPE ratios relative to no-change forecast: 1992.1-2018.8

| | **World IP index** | | **PC real commodity prices** | | **PC steel production** | | **Global activity factor** | |
|---|---|---|---|---|---|---|---|---|
| **Monthly horizon** | VAR(12) | BVAR(12) | VAR(12) | BVAR(12) | VAR(12) | BVAR(12) | VAR(12) | BVAR(12) |
| 1 | **0.932** | **0.884**** | **0.943** | **0.888**** | **0.951** | **0.904*** | **0.971** | **0.902*** |
| 3 | **0.892** | **0.888** | **0.938** | **0.906** | **0.950** | **0.943** | 1.002 | **0.956** |
| 6 | **0.962** | **0.932** | **0.978** | **0.938** | **0.984** | **0.978** | 1.055 | 1.008 |
| 9 | 1.028 | **0.976** | 1.061 | 1.002 | 1.001 | **0.994** | 1.060 | 1.035 |
| 12 | 1.033 | **0.979** | 1.061 | **0.985** | **0.980** | **0.977** | 1.012 | 1.005 |
| 18 | **0.945** | **0.943** | **0.978** | **0.934** | **0.943** | **0.955** | **0.906** | **0.956** |
| 24 | **0.911** | **0.919** | **0.934** | **0.903** | **0.928** | **0.932** | **0.860** | **0.911** |

Notes: **Bold** indicates that the model performs better than the random walk;

Green indicates whether the VAR or BVAR does better;

Blue indicates the best model among the alternative global economic activity indicators.

# Does Time Variation Matter?

- Structural changes that shape the demand for energy
  - ➢ shifts in energy intensity of production and consumption
  - ➢ changes in the energy mix
  - ➢ technological progress
  - ➢ changes in capacity constraints
- 2 potential sources of time variation:
  - ➢ changes in the dynamic relationship between variables
  - ➢ changes in the volatility

$\Rightarrow$ Time variation in coefficients detrimental to forecast accuracy

BUT stochastic volatility improves long-run forecasts

# The Role of Stochastic Volatility

Recursive MSPE ratios relative to no-change forecast: 1992.1-2018.8

| Monthly horizon | Kilian index (REA BDI) | REA *Shipping Insight* | PC real shipping costs | World IP index | PC real commodity prices | PC steel production | Global activity factor |
|---|---|---|---|---|---|---|---|
| | | | (a) Production-Based Models | | | | |
| 1 | **0.911**$^{**}$ | **0.911**$^{**}$ | **0.913**$^{**}$ | **0.905**$^{**}$ | **0.919**$^{**}$ | **0.924**$^{*}$ | **0.935**$^{*}$ |
| 3 | **0.972** | **0.957** | **0.942** | **0.942** | **0.954** | **0.952** | **0.962** |
| 6 | 1.024 | 1.009 | **0.949**$^{*}$ | **0.966** | **0.963** | **0.972** | **0.969** |
| 9 | 1.039 | 1.022 | **0.931**$^{*}$ | **0.939**$^{*}$ | **0.952** | **0.943** | **0.951** |
| 12 | 1.046 | 1.023 | **0.899**$^{**}$ | **0.910**$^{*}$ | **0.913**$^{**}$ | **0.906**$^{*}$ | **0.914**$^{*}$ |
| 18 | **0.940** | **0.932** | **0.837**$^{**}$ | **0.839**$^{**}$ | **0.831**$^{**}$ | **0.844**$^{**}$ | **0.851**$^{**}$ |
| 24 | **0.827** | **0.838** | **0.765**$^{**}$ | **0.768**$^{**}$ | **0.767**$^{**}$ | **0.762**$^{**}$ | **0.769**$^{**}$ |
| | | | (a) Consumption-Based Models | | | | |
| 1 | **0.920**$^{*}$ | **0.910**$^{**}$ | **0.907**$^{**}$ | **0.905**$^{**}$ | **0.911**$^{**}$ | **0.912**$^{**}$ | **0.928**$^{**}$ |
| 3 | **0.958** | **0.939**$^{*}$ | **0.909** | **0.918**$^{*}$ | **0.939**$^{*}$ | **0.929** | **0.940** |
| 6 | 1.018 | **0.987** | **0.910**$^{**}$ | **0.926**$^{*}$ | **0.943**$^{*}$ | **0.925**$^{*}$ | **0.947** |
| 9 | 1.063 | 1.021 | **0.897**$^{*}$ | **0.911**$^{*}$ | **0.937**$^{*}$ | **0.909**$^{*}$ | **0.937** |
| 12 | 1.072 | 1.031 | **0.874**$^{**}$ | **0.869**$^{**}$ | **0.887**$^{**}$ | **0.864**$^{**}$ | **0.898**$^{*}$ |
| 18 | **0.951** | **0.928** | **0.789**$^{**}$ | **0.790**$^{**}$ | **0.783**$^{**}$ | **0.791**$^{**}$ | **0.815**$^{*}$ |
| 24 | **0.821** | **0.811** | **0.719**$^{**}$ | **0.710**$^{**}$ | **0.718**$^{**}$ | **0.710**$^{**}$ | **0.717**$^{**}$ |

Notes: **Bold** indicates that model performs better than random walk;
Red indicates the best model among the shipping indices;
Blue indicates the best model among the alternative global economic activity indicators.

# Petroleum Consumption Forecasts

Recursive MSPE ratios relative to AR(12) benchmark: 1992.1-2018.8

| **Monthly horizon** | **Kilian index (REA BDI)** | **REA *Shipping Insight*** | **PC real shipping costs** | **World IP index** | **PC real commodity prices** | **PC steel production** | **Global activity factor** |
|---|---|---|---|---|---|---|---|
| | | | | (a) BVAR(12) | | | |
| 1 | 1.103 | 1.084 | 1.046 | 1.002 | 1.054 | 1.255 | 1.089 |
| 3 | 1.445 | 1.397 | 1.134 | 1.252 | 1.173 | 1.609 | 1.461 |
| 6 | 2.062 | 1.994 | 1.310 | 1.511 | 1.335 | 1.794 | 1.933 |
| 9 | 2.558 | 2.463 | 1.421 | 1.532 | 1.440 | 1.834 | 2.088 |
| 12 | 3.131 | 3.018 | 1.521 | 1.635 | 1.523 | 2.007 | 2.317 |
| 18 | 3.838 | 3.658 | 1.781 | 1.870 | 1.759 | 2.437 | 2.482 |
| 24 | 4.122 | 3.870 | 2.055 | 2.043 | 1.977 | 2.553 | 2.432 |
| | | | | (b) BVAR(12) with stochastic volatility | | | |
| 1 | **0.968** | **0.963*** | **0.962*** | **0.933**** | **0.949**** | **0.954**** | **0.935**** |
| 3 | 1.073 | 1.069 | 1.036 | **0.984** | 1.017 | 1.026 | **0.992** |
| 6 | 1.213 | 1.184 | 1.064 | 1.009 | 1.070 | 1.059 | 1.000 |
| 9 | 1.274 | 1.245 | 1.087 | **0.995** | 1.108 | 1.065 | **0.955** |
| 12 | 1.369 | 1.340 | 1.114 | 1.013 | 1.154 | 1.095 | **0.946** |
| 18 | 1.561 | 1.542 | 1.178 | 1.048 | 1.245 | 1.130 | **0.976** |
| 24 | 1.645 | 1.652 | 1.208 | 1.052 | 1.304 | 1.141 | **0.950** |

Notes: **Bold** indicates that model outperforms AR(12); blue indicates best model among set of models.

# The Benefits of Variable Selection

- Is more information always better?
  - ⇨ dataset contains large number of heterogeneous variables
- Does a subset of variables outperform the large dataset?
  - ⇨ variables with highest loadings on factor
  - ⇨ variables with broadest coverage representative of each group
    - ➢ Macroeconomic variables: world IP, Conference Board leading economic indicator, OECD consumer confidence
    - ➢ Commodity prices: real copper prices
    - ➢ Uncertainty measures: global political risk indicator, long-run oil price uncertainty
    - ➢ Financial data: MSCI world index, stock returns in transportation sector, real trade-weighted US dollar index
    - ➢ Weather-related: El Nino, residential energy demand temperature index
    - ➢ Transportation: OECD passenger car registration, US vehicle miles traveled
    - ➢ Expectations: spread between long-run and short-run oil price expectations, index of consumer expectations (Michigan survey)
    - ➢ Energy-related: energy production and distribution EU28

# The Benefits of Variable Selection

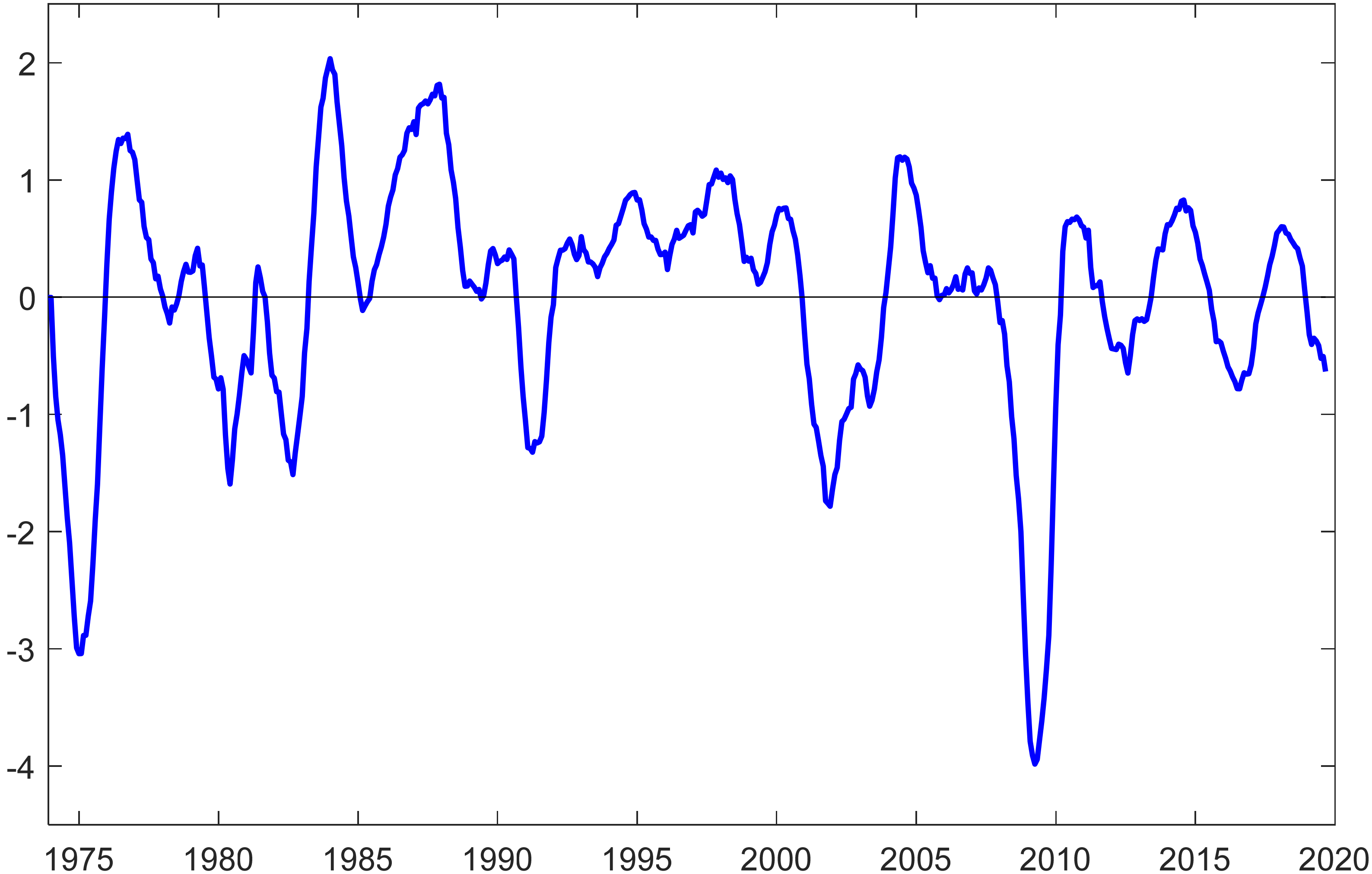
Recursive MSPE ratios relative to benchmark model: 1992.1-2018.8

| | Monthly horizon | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 3 | 6 | 9 | 12 | 18 | 24 |
| **(a) Brent Price Forecasts** | | | | | | | |
| Global activity factor | **0.928**$^{**}$ | **0.940** | **0.947** | **0.937** | **0.898**$^{*}$ | **0.815**$^{*}$ | **0.717**$^{**}$ |
| 16 variables: highest loading | **0.912**$^{**}$ | **0.920** | **0.926**$^{*}$ | **0.900**$^{*}$ | **0.851**$^{**}$ | **0.760**$^{**}$ | **0.680**$^{**}$ |
| 16 variables: "broadest coverage" in groups | **0.922**$^{**}$ | **0.932** | **0.939** | **0.923** | **0.878**$^{*}$ | **0.801**$^{*}$ | **0.702**$^{**}$ |
| **(b) Consumption Forecasts** | | | | | | | |
| Global activity factor | **0.935**$^{**}$ | **0.992** | 1.000 | **0.955** | **0.946** | **0.976** | **0.950** |
| 16 variables: highest loading | **0.949**$^{**}$ | **0.997** | 1.010 | **0.984** | 1.016 | 1.049 | 1.034 |
| 16 variables: "broadest coverage" in groups | **0.936**$^{**}$ | **0.948** | **0.930** | **0.870**$^{*}$ | **0.872** | **0.909** | **0.883** |

Notes: **Bold** indicates that model outperforms benchmark model (no-change forecast for the Brent price, AR(12) for consumption).

# The Global Activity Factor

- Factor extracted from 16 variables with broadest coverage representative of each group for the period 1973.2-2019.8



# The Role of Real-Time Data Constraints

- 3 aspects:
  - ➢ data revisions
  - ➢ delays in data availability
  - ➢ some variables did not exist in real time

  ⇨ mimic real-time nature of lags in data releases

  ⇨ propose simple now-casting techniques to fill gaps

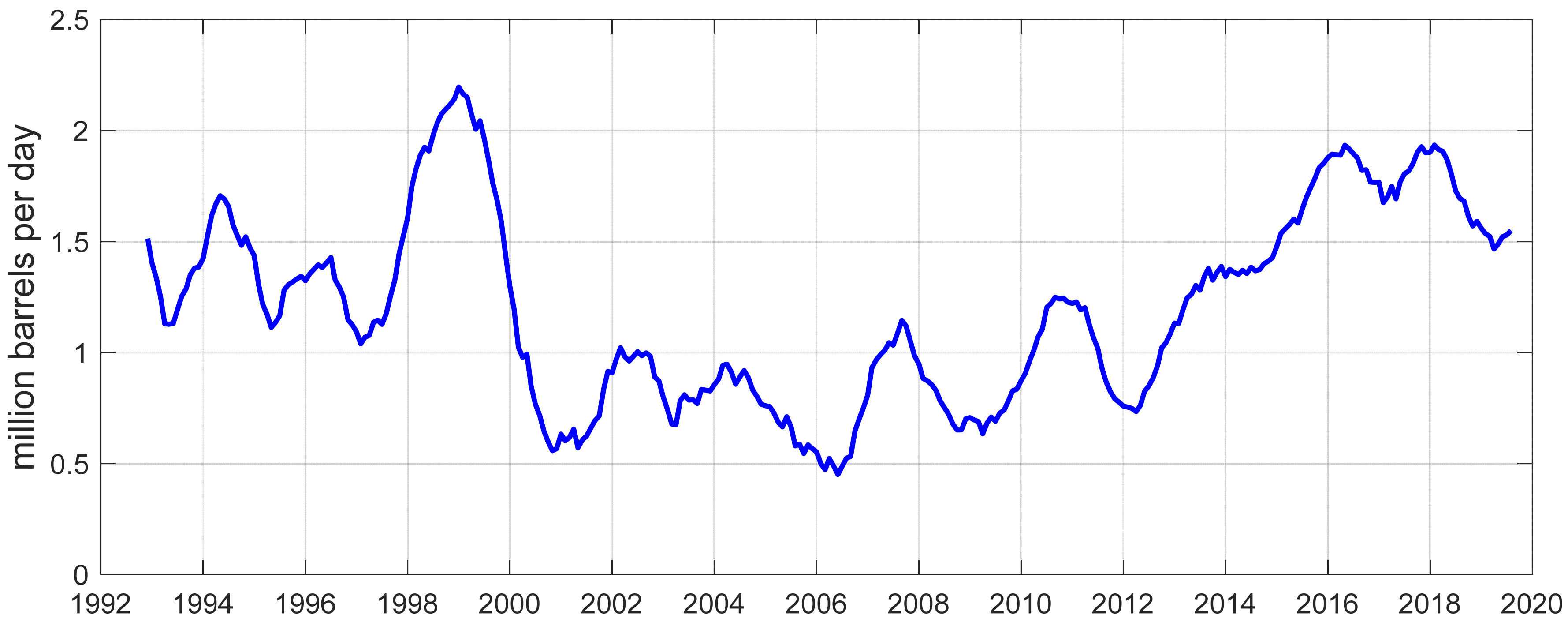
- Baumeister and Kilian (2012): timely availability of more accurate data on nominal oil price has highest payoff

  ⇨ Brent price is available in real time

| | Real Brent Price | | Global Petroleum Consumption | |
|---|---|---|---|---|
| Monthly horizon | Pseudo real time | Real-time data | Pseudo real time | Real-time data |
| 1 | **0.922**$^{**}$ | **0.926**$^{*}$ | **0.936**$^{**}$ | **0.945**$^{**}$ |
| 2 | **0.929**$^{*}$ | **0.937** | **0.925**$^{**}$ | **0.913**$^{**}$ |
| 3 | **0.932** | **0.941** | **0.948** | **0.964**$^{*}$ |
| 4 | **0.940** | **0.959** | **0.925** | **0.924**$^{**}$ |
| 5 | **0.938** | **0.952** | **0.937** | **0.922**$^{**}$ |
| 6 | **0.939** | **0.958** | **0.930** | **0.931** |
| 7 | **0.935** | **0.957** | **0.904** | **0.873**$^{**}$ |
| 8 | **0.923** | **0.941** | **0.894** | **0.871**$^{**}$ |
| 9 | **0.923** | **0.937** | **0.870**$^{*}$ | **0.920** |
| 10 | **0.912** | **0.918** | **0.894** | **0.904**$^{*}$ |
| 11 | **0.898**$^{*}$ | **0.899**$^{*}$ | **0.902** | **0.917**$^{*}$ |
| 12 | **0.878**$^{*}$ | **0.886**$^{*}$ | **0.872** | **0.927** |
| 13 | **0.867**$^{*}$ | **0.873**$^{*}$ | **0.889** | **0.907** |
| 14 | **0.856**$^{*}$ | **0.854**$^{*}$ | **0.882** | **0.906**$^{*}$ |
| 15 | **0.837**$^{*}$ | **0.835**$^{*}$ | **0.885** | **0.905** |
| 16 | **0.816**$^{**}$ | **0.821**$^{**}$ | **0.897** | **0.896** |
| 17 | **0.806**$^{**}$ | **0.806**$^{**}$ | **0.910** | **0.935** |
| 18 | **0.801**$^{*}$ | **0.794**$^{**}$ | **0.909** | **0.936** |
| 19 | **0.785**$^{**}$ | **0.785**$^{**}$ | **0.900** | **0.905** |
| 20 | **0.766**$^{**}$ | **0.768**$^{**}$ | **0.914** | **0.923** |
| 21 | **0.755**$^{**}$ | **0.745**$^{**}$ | **0.890** | **0.910** |
| 22 | **0.733**$^{**}$ | **0.729**$^{**}$ | **0.889** | **0.910** |
| 23 | **0.716**$^{**}$ | **0.715**$^{**}$ | **0.879** | **0.904** |
| 24 | **0.702**$^{**}$ | **0.698**$^{**}$ | **0.883** | **0.907** |

# Growth in Expected Demand over Next Year

- Indicator of expected demand pressures




- Computed as difference between the 13-month-ahead and the 1-month-ahead forecast of petroleum consumption

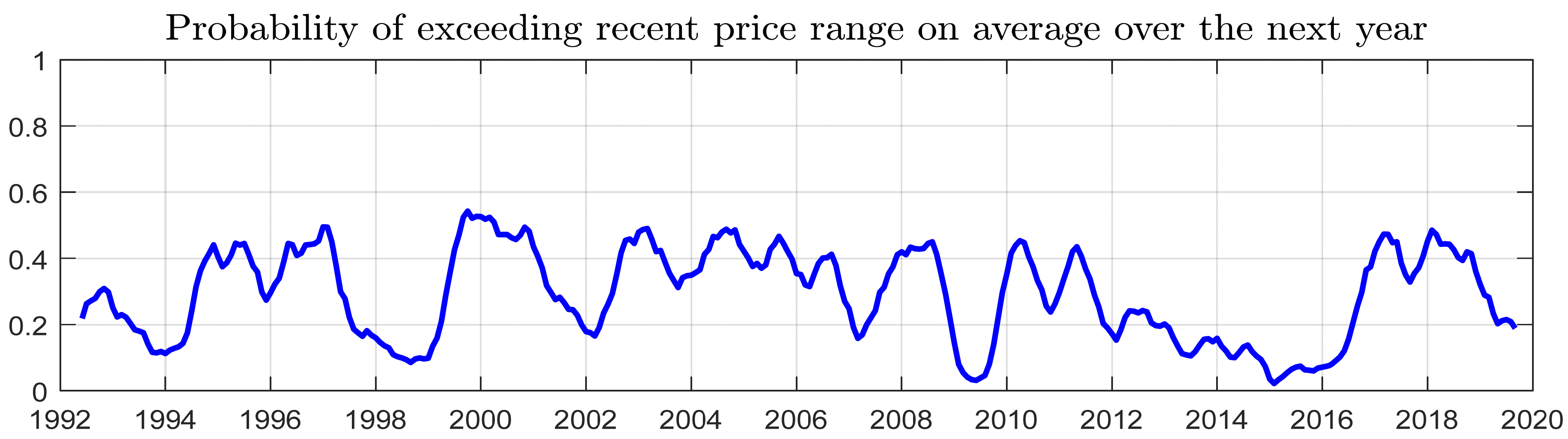
# Price Pressure Measures

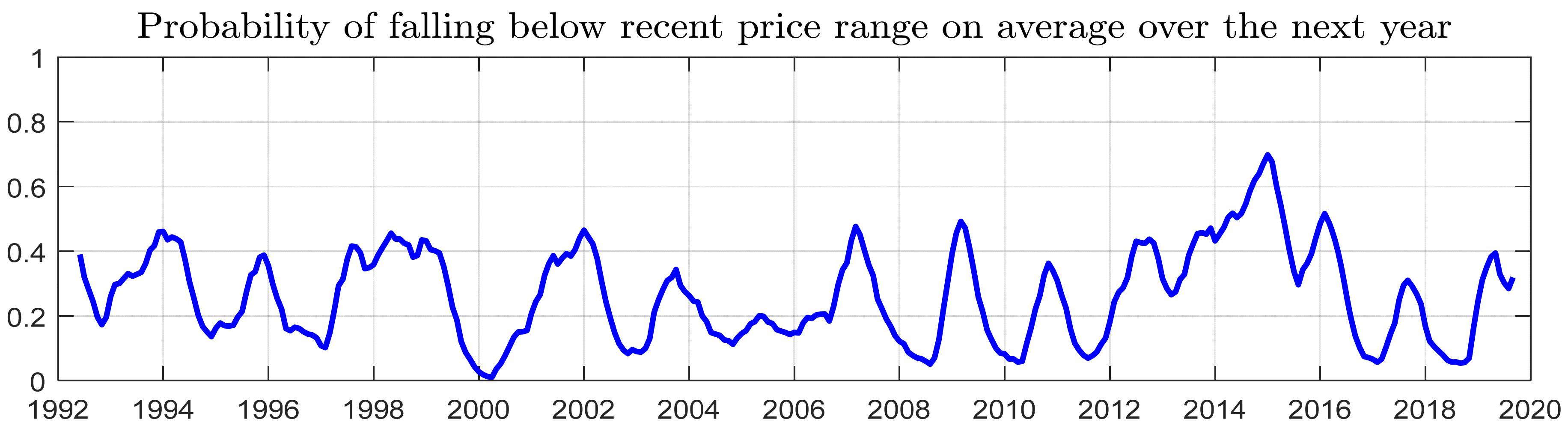
- Assess the probability that the price of oil will exceed or fall below last year's price range

⇨ construct an index that measures the likelihood that the expected oil price will rise above (or drop below) recent price band over the next 12 months on average:

$$PPM = \sum_{h=0}^{12} w_h \Pr(p_{t+h|t}^{oil} > p_{t:t-12}^{oil})$$

# Price Pressure Measures

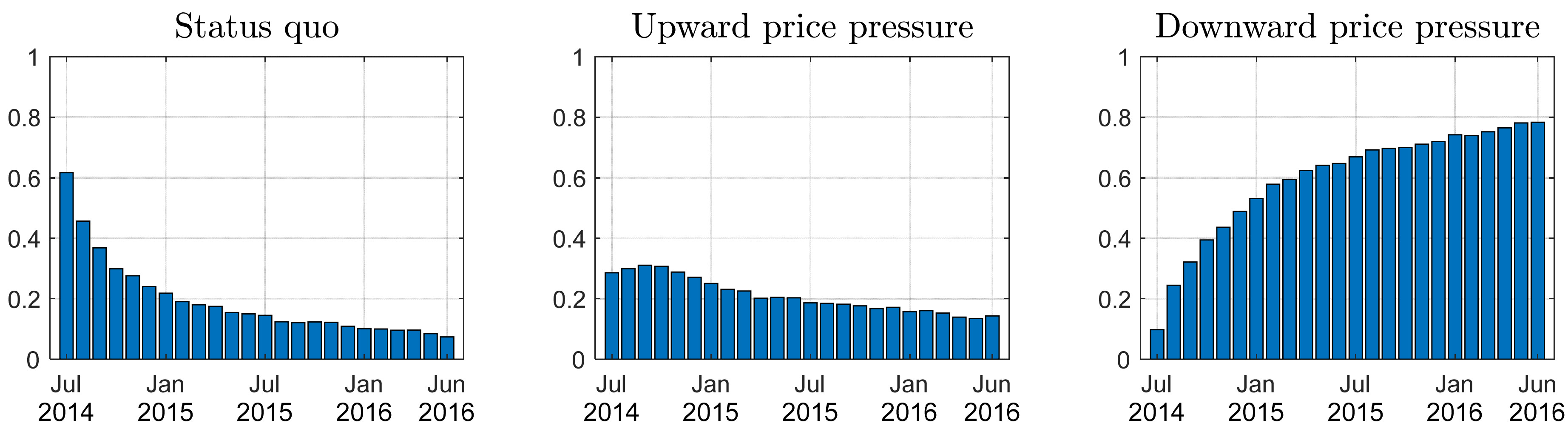


# Expected Price Pressures in June 2014

- Between June 2013 and June 2014 the Brent price fluctuated between $103 and $112

⇨ What was the predicted probability that Brent would stay within that range, exceed it, or fall below it?

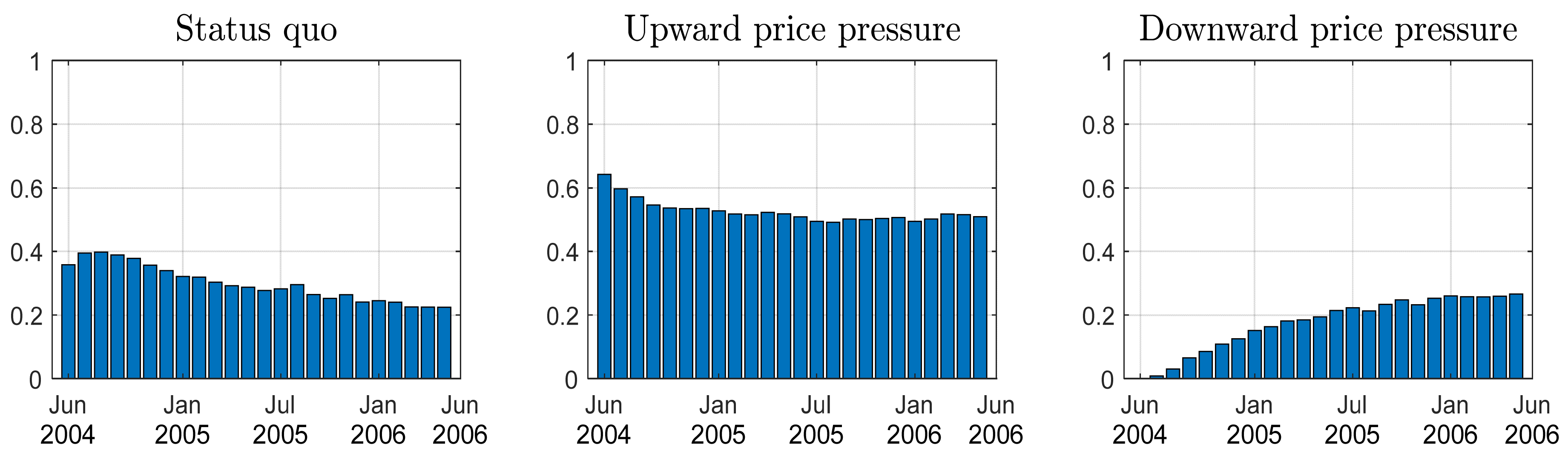



- In June 2016, the Brent price was $48.

# Expected Price Pressures in May 2004

- Between May 2003 and May 2004 the Brent price fluctuated between $26 and $38

⇨ What was the predicted probability that Brent would stay within that range, exceed it, or fall below it?




- In May 2006, the Brent price was $70.

# Key Takeaways

- For short-term oil price forecasts, consumption-based model with world industrial production performs best
  ⇨ MSPE reductions of 12% 1-month ahead and 7% 6-month ahead

- For long-term oil price forecasts, stochastic volatility is an important feature
  ⇨ MSPE reductions of 29% at the 2-year horizon (across indicators)

- For forecasting the real price of Brent and global petroleum consumption jointly, the best model uses a global activity factor extracted from a small set of key determinants of energy demand
  ⇨ indicator of expected demand
  ⇨ expectations about price pressures